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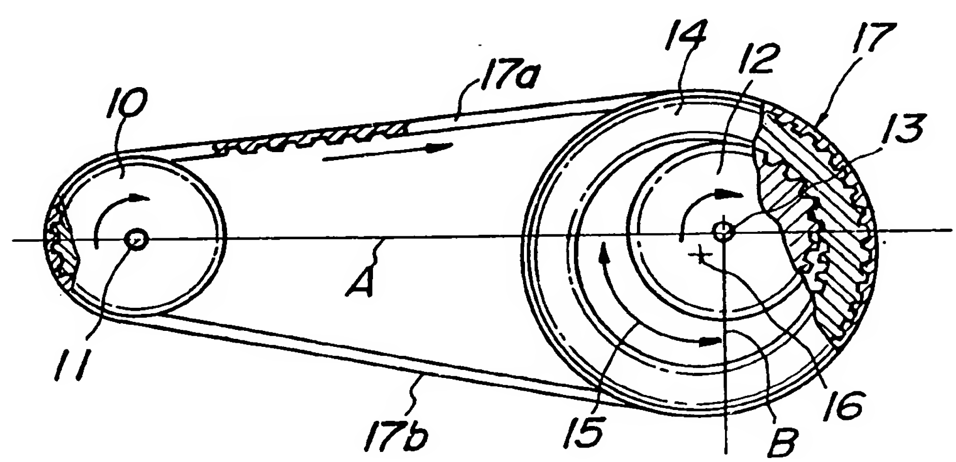
(54) Belt gearing

(57) In transmitting rotary power from a driving wheel to a driven wheel 10 through a belt 17, the disclosed belt gearing uses an annular outside wheel 14 with either the driving or driven wheel, said annular outside wheel having an internal gear formed on inner circumferential surface thereof so as to operatively engage the outer circumferential surface of an inner wheel 12 disposed in the central hollow portion thereof, in order to transmit power from the outside wheel to the wheel therein. The belt extends between the outer circumferential surface of the outside wheel and the remaining one of said driving and driven wheels, and the outside wheel is displaceable relative to the inner wheel to adjust automatically the tension of said belt. The belt gearing may include a means to prevent said internal gear of the outside wheel from disengaging from said inner wheel.

FIG.2



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SPECIFICATION

A belt gearing with an automatic tension adjusting mechanism

This invention relates to a belt gearing, and more particularly to a belt gearing including an automatic tension adjusting mechanism by using a transmission assembly consisting of an annular member with an internal gear formed on inner circumference thereof and a small gear with a diameter smaller than the inside diameter of said internal gear which small gear meshes said internal gear of the annular member. The present invention also relates to a belt gearing of the aforesaid type having a means to prevent said internal gear from disengaging from meshing with said small gear.

A belt gearing of the prior art using a toothed belt (known by a trademark of timing belt) extending between a driving wheel and a driven wheel has shortcomings in that, when driving force acting on the belt becomes large, the toothed belt is elongated on driving side thereof while non-driving side of the belt is loosened, so that the loosened portion of the belt tends to ride on teeth of the driven wheel when the belt comes in contact with the driven wheel, resulting in non-driving rotation thereof. To avoid such non-driving rotation, a tension roller biased by a spring is provided so as to engage the loosened side of the belt, whereby a supplementary tension is applied to the loosened portion of the belt. However, the tension roller of the prior art has shortcomings in that, when the non-driving side of the belt is loosened and slackened in excess of a certain limit, the tension of the loosened portion of the belt tends to become very small and the non-driving rotation is easily caused. Thus, the tension roller of the prior art is not an ideal means to automatically control the tension of the belt in a belt gearing.

Therefore, an object of the present invention is to obviate the aforesaid shortcomings of the prior art by providing an improved belt gearing with an automatic tension adjusting mechanism. In an embodiment of the belt gearing of the invention, a belt extends between a driving wheel and an annular driven member which engages a driven wheel, and the distance between the axes of said driving wheel and said driven annular member varies depending on the driving force acting on the belt, so as to automatically optimize the belt tension. Whereby, the belt is prevented from any non-driving rotation, and the durability of the belt is improved.

To fulfil the aforesaid object, a preferred embodiment of the present invention comprises a driven wheel with an axial center thereof disposed on one line, a driving inside wheel with an axial center thereof disposed on said one line, said driving inside wheel having teeth formed on circumference thereof, a driving outside wheel of annular shape whose axial center is displaceable, said driving outside wheel having an internal gear formed on inner circumferential surface thereof, said internal gear meshing said teeth on said driving inside wheel, and a belt drivingly engaging said driven wheel and said driving outside wheel, said belt having a length to allow the axial center of said driving outside wheel to displace in a loose side offset zone defined on loose side of said belt by said one line and a perpendicular to said one line at the axial center of said driving inside wheel, so as to automatically adjust tension of said belt.

Another preferred embodiment of the present invention comprises a driving wheel with an axial center thereof disposed on one line, a driven inside wheel with an axial center thereof disposed on said one line, said driven inside wheel having teeth formed on circumference thereof, a driven outside wheel of annular shape whose axial center is displaceable, said driven outside wheel having an internal gear formed on inner circumferential surface thereof, said internal gear meshing said teeth on said driven inside wheel, and a belt drivingly engaging said driving wheel and said driven outside wheel, said belt having a length to allow said axial center of said driven outside wheel to displace in a loose side offset zone defined on loose side of said belt by said one line and a perpendicular to said one line at the axial center of said driven inside wheel, so as to automatically adjust tension of said belt.

Another object of the present invention is to provide a belt gearing having either the aforesaid driving inside wheel meshing the aforesaid internal gear of the driving outside wheel or the aforesaid driven inside wheel meshing the aforesaid internal gear of the driven outside wheel, wherein said belt gearing includes a disengage-preventing means having a guide plate means secured to at least one side surface of either one of said driving inside wheel and said driving outside wheel or one of said driven inside wheel and said driven outside wheel, so as to guide sidewalls of said meshing wheels to prevent said internal gear from disengaging from the wheel meshing therewith.

A further object of the present invention is to provide a belt gearing of the last mentioned type with said disengage-preventing means, wherein at least a portion of the circumference of said guide plate means extends outwardly in excess of outer surface of the aforesaid belt at a position where said belt engages either said driving outside wheel or said driven outside wheel.

For a better understanding of the invention reference is made to the accompanying drawings, in which:

Fig. 1 is a partially cutaway schematic side view of a belt gearing of the prior art using a toothed belt;

Fig. 2 is a partially cutaway schematic side view of a first embodiment of the belt gearing according to the present invention;

Figure 3 is a partially cutaway schematic side view of a second embodiment of the belt gearing according to the present invention;

Fig. 4 is an explanatory diagram, showing the operation of the present invention;

Fig. 5 is a partially cutaway side view of a belt

gearing which has an automatic tension adjusting mechanism and a disengage-preventing means according to the present invention;

Fig. 6 is a sectional taken along the line VI—VI of Fig. 5;

Fig. 7 is a schematic side view of a modification of the belt gearing of Fig. 5 according to the present invention; and

Fig. 8 is a sectional view taken along the line VIII—VIII of Fig. 7.

In Fig. 1, 1 is a driving wheel, 2 is a driven wheel, 3 is a belt, 3a is a driving side of the belt, 3b is loose side of the belt, 4 is a spring, and 5 is a tension roller. In Fig. 2 through Fig. 4, 10 is a driven wheel, 11 is an axial center of the driven wheel, 12 is a driving inside wheel, 13 is an axial center of the driving inside wheel, 14 is a driving outside wheel, 15 is a loose side offset zone, 16 is an axial center of the driving outside wheel, 17 is a belt, 17a is a driving side of the belt, 17b is loose side of the belt, 20 is a driving wheel, 21 is an axial center of the driving wheel, 22 is a driven inside wheel, 23 is an axial center of the driven inside wheel, 24 is a driven outside wheel, 25 is a loose side offset zone, 26 is an axial center of the driven outside wheel, 27 is a belt, 27a is driving side of the belt, and 27b is loose side of the belt. In Fig. 5 through Fig. 8, 31 is a driving pulley, 31a shows teeth to mesh a toothed belt, 31b is an internal gear, 32 is a driven pulley, 33 is a toothed belt, 34 is a driving gear wheel, 35 is a driving shaft, 36 is a guide plate, 37 is a bolt, and 38 is a nut.

Before entering the details of the invention, a belt gearing of the prior art will be briefly reviewed by referring to Fig. 1. A typical belt gearing of the prior art has a driving wheel 1, a driven wheel 2, a toothed belt 3 extending therebetween. When a large driving force is applied to the toothed belt 3, the driving side 3a of the belt 3 is elastically elongated while causing the loose side 3b of the belt 3 to be slacked. As a result, the slackened portion of the belt 3 tends to ride on the driven wheel 2 when the belt 3 comes into contact with the driven wheel 2, resulting in non-driving rotation which is a shortcoming of the belt gearing of the prior art. To overcome this shortcoming, it has been practiced to use a tension roller 5 resiliently urged to the loose side 3b of the belt 3 by a spring 4, so as to prevent the loose side 3b from being excessively slackened.

However, if the amount of the slackening of the loose side 3b of the belt 3 becomes large as shown by the dash-dot-dot line 3b' of Fig. 1, the elongation of the spring 4 acting on the tension roller 5 becomes large and the resilient force to upwardly urge the tension roller 5 decreases, so that the tension of the loose side 3b becomes inversely proportional to the driving force. More particularly, for certain large tension on the driving side 3a of the belt 3, the tension on the loose side 3b of the belt 3 becomes small, so that the non-driving rotation may be easily caused. Thus, the mechanism of the prior art as shown in Fig. 1 does not provide ideal means to adjust the belt tension in response to the driving force.

In a first embodiment of the belt gearing of the invention shown in Fig. 2, a driven wheel 10 has an axial center 11 thereof disposed on one line A, and a driving inside wheel 12 has an axial center 13 thereof disposed on the same line A. An annular driving outside wheel 14, which is displaceable, has an internal gear formed on inner circumferential surface thereof, and the driving inside wheel 12 has gear teeth formed on the outer circumferential surface thereof so as to mesh the internal gear of the driving outside wheel 14. A loose side offset zone 15 below the aforesaid line A is defined by the aforesaid line A and a perpendicular B to line A extending downward from the axial center 13 of the driving inside wheel 12, and the driving outside wheel 14 has an axial center 16 thereof displaceable in the loose side offset zone 15. A toothed belt 17 extends between the driving outside wheel 14 and the driven wheel 10, and the length of the belt 17 is so selected as to allow the aforesaid displacement of the axial center 16 of the driving outside wheel 14. The driving side 17a of the belt 17 extends above the aforesaid line A from the driven wheel 10 to the driving outside wheel 14, while the loose side 17b of the belt 17 extends below the aforesaid line A from the driving outside wheel 14 to the driven wheel 10. Although the illustrated embodiment uses a toothed belt, the present invention is not restricted to the use of the toothed belt.

Fig. 3 shows another embodiment of the invention, in which a driving wheel 20 has an axial center 21 thereof disposed on one line A and a driven inside wheel 22 has an axial center 23 thereof disposed on the line A. The driven inside wheel 22 has gear teeth formed on the circumference thereof, which gear teeth mesh an internal gear formed on the inner circumferential surface of an annular driven outside wheel 24. A loose side offset zone 25 below the aforesaid line A is defined by the aforesaid line A and a perpendicular B to the line A extending downward from the axial center 23 of the driven inside wheel 22, and the driven outside wheel 24 is displaceable while keeping an axial center 26 thereof in the loose side offset zone 25. A toothed belt 27 extends between the driving wheel 20 and the driven outside wheel 24, and the length of the belt 27 is so selected as to allow the aforesaid displacement of the driven outside wheel 24 with its axial center 26 kept in the loose side offset zone 25. The driving side 27A of the belt 27 extends above the aforesaid line A from the driven outside wheel 24 to the driving wheel 20, while the loose side 27b of the belt 27 extends below the aforesaid line A from the driving wheel 20 to the driven outside wheel 24.

In short, the embodiment of Fig. 3 is made by using the displaceable driving gear means of the embodiment of Fig. 2 as a displaceable driven gear means in Fig. 3, while making the driving wheel of Fig. 3 not displaceable.

The operation and effect of the belt gearing

with the aforementioned construction according to the present invention will be now explained by referring to Fig. 4. In the figure, the driving inside wheel 12 engages the driving outside wheel 14 at a point S. A perpendicular C from the point S to an upper tangent to both the driven wheel 10 and the driving outside wheel 14 has a foot T, which upper tangent represents the line of the driving side 17a of the belt 17. A perpendicular D from the point S to the lower tangent to both the driven wheel 10 and the driving outside wheel 14 has a foot I, which lower tangent represents the line of the loose side 17b of the belt 17. When the driving inside wheel 12 rotates in a clockwise direction, a driving force X is applied to the driving side 17a of the belt 17 through the driving outside wheel 14. If the length of the perpendicular C from the point S to the foot T is represented by TS and the length of the perpendicular D between the point S and the foot I is represents by IS, then the tension applied to the loose side 17b of the belt 17 under the aforesaid conditions is given by (TS/IS)X.

Accordingly, the tension on the loose side 17b of the belt 17 never exceeds the tension caused on the driving side 17a of the belt 17, and the tension on the loose side 17b of the belt 17 is substantially proportional to the tension on the driving side 17a thereof. As a result, the aforesaid construction of the invention effectively prevents the riding of the belt 17 on the driven wheel as the belt comes into contact with the driven wheel and the ensuing non-driving rotation, which riding and non-driving rotation occur in the belt gearing of the prior art. In the foregoing, the operation of the embodiment of Fig. 2 is explained by referring to Fig. 4, and the operation of the embodiment of Fig. 3 is apparent to those skilled in the art from the foregoing description, so that the description of the operation will not be repeated here on the embodiment of Fig. 3. Although the belt gearing of the invention is advantageously applied to driving mechanisms of bicycles, the present invention can be used in and applied to many other industrial mechanisms.

As described in the foregoing, the belt gearing of the invention eliminates the tension roller which has been used in the prior art, and the effective spacing between the driving wheel and the driven wheel is automatically changed substantially in proportion to the magnitude of the driving force, so as to provide a loose side tension of the belt which matches the driving side tension thereof, whereby the belt is prevented from the non-driving rotation and the durability of the belt is improved. Moreover, in the belt gearing of the invention, the resistance to driving can be kept optimal at different loadings, and the automatic tension adjusting mechanism of the belt gearing according to the invention can be easily applied to a wide variety of industrial fields.

Fig. 5 through Fig. 8 show two other embodiments of the invention. In the embodiment of Fig. 5, an annular driving pulley 31, which corresponds to the driving outside wheel 14 of Fig. 2, has teeth 31a formed on the outer circumferential surface thereof so as to mesh the teeth of a toothed belt 33 and an internal gear 31b formed on the inner circumferential surface thereof. A driven pulley 32 has gear teeth 32a formed on the outer circumferential surface thereof so as to mesh the toothed belt 33 extending between the driving pulley 31 and the driven pulley 32. A driving gear wheel 34, which corresponds to the driving inside wheel 12 of Fig. 2, meshes the aforesaid internal gear 31b and is integrally secured to a driving shaft 35.

Referring to Figs. 5 and 6, a pair of annular guide plates 36 are provided on opposite surfaces of the driving pulley 31 of this embodiment. The guide plates 36 are secured to the driving pulley 31 by bolts 37 and nuts 38, so as to hold the driving gear wheel 34 between the two guide plates 36.

Figs. 7 and 8 illustrate another embodiment of the invention, in which a pair of annular guide plates 36 are secured to a driving gear wheel 34 by bolts 37 and nuts 38. At least a portion of the outer circumferential edge of each guide plate 36 extends outwardly in excess of the outside surface of the toothed belt 33 at a position where the belt 33 engages the driving pulley 31. If it is desired to guide the belt 33 at the position where the belt 33 engages the driving wheel 31 by using the guide plates 36 secured to the annular driving pulley having the internal gear 31b, the outside diameter of the guide plate 36 must be larger than the diameter of the driving pulley 31 with the belt 33 wound thereon. If the guide plates 36 are mounted on the driving gear 34 as shown in Figs. 7 and 8, the guiding of the belt 33 at the position where the belt 33 engages the driving pulley 31 can be achieved with a considerably small outside diameter of the guide plate 36, because the driving pulley 31 is displaced relative to the driving gear wheel 34 and a portion of the outer circumferential edge of the guide plate 36 extends outwardly in excess of the outer surface of the belt 33 at the position where the belt 33 engages the driving pulley 31.

The function and effects of the guide plates 36 will now be explained.

The internal gear formed on the inner circumferential surface of a displaceable annular driving pulley and loosely engaging a gear wheel tends to disengage from the gear wheel due to various reasons; namely, inclination of tooth surfaces caused by machining error, accelerated abrasion of the tooth surfaces due to uneven contacts of the coacting teeth, and uneven abrasion of the tooth surfaces caused by repeated frictional contacts during long surface life thereof. The aforesaid inclination, accelerated abrasion, and uneven abrasion tend to generate lateral movement component of the internal gear in the direction of the axis of rotation thereof, leading to disengagement of the internal gear from the gear wheel. Although the generation of the aforementioned lateral movement component in the loosely meshed pair of the internal gear and the gear wheel can be suppressed by using double

helical gear teeth in the pair, when the belt gearing with the automatic tension adjusting mechanism of the aforesaid construction of the invention is mounted on bicycles, vehicles, or other moving machines, the internal gear loosely meshing the gear wheel tends to disengage from the gear wheel due to vibrations or inclined operation thereof even if the double helical gear teeth are used therein.

The present invention prevents such disengagement of the internal gear from the gear wheel loosely meshing therewith in a dependable fashion, by mounting an annular guide plate means to either one of the internal gear and the gear wheel.

More particularly, in an automatic tension adjusting mechanism of a belt 33 which extends between a displaceable annular pulley 31 with an internal gear 31b formed on the inner circumferential surface thereof so as to loosely mesh a gear wheel 34 and a pulley 32 spaced from said annular pulley 31 by a variable distance, the annular pulley 31 having the internal gear 31b is suceptible to the aforesaid lateral movement relative to the gear wheel 34. The present invention prevents the aforesaid lateral movement and the ensuing disengagement of the internal gear 31b from the gear wheel 34 by mounting an annular guide plate means 36 on the sidewall of either of the internal gear 31b and the gear wheel 34. Accordingly, the present invention improves the durability of gear teeth by the aforementioned prevention of the lateral movement of the internal gear, whereby the disengagement of the internal gear from a coacting gear wheel is prevented even under vibrated or inclined conditions, and the industrial fields to which the belt gearing with the automatic tension adjusting mechanism is considerably expanded.

In the embodiments of the invention illustrated in Figs. 5 through 8, the internal gear is provided on a driving pulley, but it is also possible to provide an internal gear on a driven pulley 32 and to mount the guide plate means on either the thus provided internal gear of the driven wheel pulley or a gear wheel coacting with the internal gear, so as to fulfil the aforesaid functions and effects of the invention.

In the embodiment of Figs. 7 and 8, a portion of the circumferential edge of the guide plate means 36 always guides the belt 33 before and during the engagement of the belt 33 with the pulley 31, so that flanges of the pulley can be dispensed with. Especially, when the pulley is provided with teeth to coact with a toothed belt, the elimination of the flanges greatly improves the efficiency of machining the pulley and facilitates mass-production of the pulley.

Although the invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in details of construction and the combination and arrangement of parts may be resorted to without departing from the scope of the invention as hereinafter claimed.

CLAIMS

1. A belt gearing with an automatic tension adjusting mechanism, comprising a driven wheel with an axial center thereof disposed on one line, a driving inside wheel with an axial center thereof disposed on said one line, said driving inside wheel having teeth formed on circumference thereof, a driving outside wheel of annular shape whose axial center is displaceable, said driving outside wheel having an internal gear formed on inner circumferential surface thereof, said internal gear meshing said teeth of said driving inside wheel, and belt drivingly engaging said driven wheel and said driving outside wheel, said belt having a length to allow said axial center of said driving outside wheel to displace in a loose side offset zone defined on loose side of said belt by said one line and a perpendicular to said one line at the axial center of said driving inside wheel, so as to automatically adjust tension of said belt.

2. A belt gearing with an automatic tension adjusting mechanism, comprising a driving wheel with an axial center thereof disposed on one line, a driven inside wheel with an axial center thereof disposed on said one line, said driven inside wheel having teeth formed on circumference thereof, a driven outside wheel of annular shape whose axial center is displaceable, said driven outside wheel having an internal gear formed on inner circumferential surface thereof, said internal gear meshing said teeth of said driven inside wheel, and a belt drivingly engaging said driving wheel and said driven outside wheel, said belt having a length to allow said axial center of said driven outside wheel to displace in a loose side offset zone defined on loose side of said belt by said one line and a perpendicular to said one line at the axial center of said driven inside wheel, so as to automatically adjust tension of said belt.

3. A belt gearing as set forth in claim 1, wherein said belt gearing further comprises a disengage-preventing means having a guide plate means mounted on said sidewall of one of said driving outside wheel and said driving inside wheel meshing said internal gear of said driving outside wheel, so as to prevent said meshing of said driving inside wheel with said internal gear from disengaging.

4. A belt gearing as set forth in claim 3, wherein at least a portion of circumference of said guide plate means extends outwardly in excess of outer surface of said belt at a position where the said belt engages said driving outside wheel.

5. A belt gearing as set forth in Claim 2, wherein said belt gearing further comprises a disengage-preventing means having a guide plate means mounted on sidewall of one of said driven outside wheel and said driven inside wheel meshing said internal gear of said driven outside wheel, so as to prevent said meshing of said driven inside wheel with said internal gear from

disengaging.

6. A belt gearing as set forth in claim 5, wherein at least a portion of circumference of said guide plate means extends outwardly in excess of outer surface of said belt at a position where said belt engages said driven outside wheel.

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FIG.1
PRIOR ART

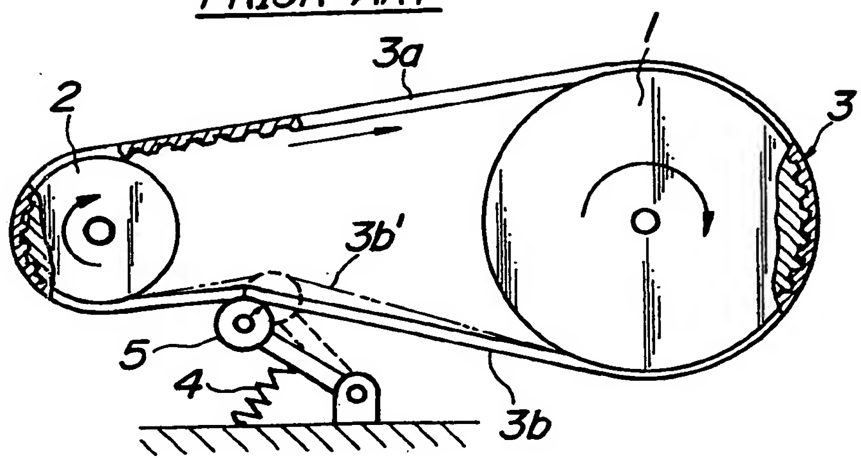

FIG.2

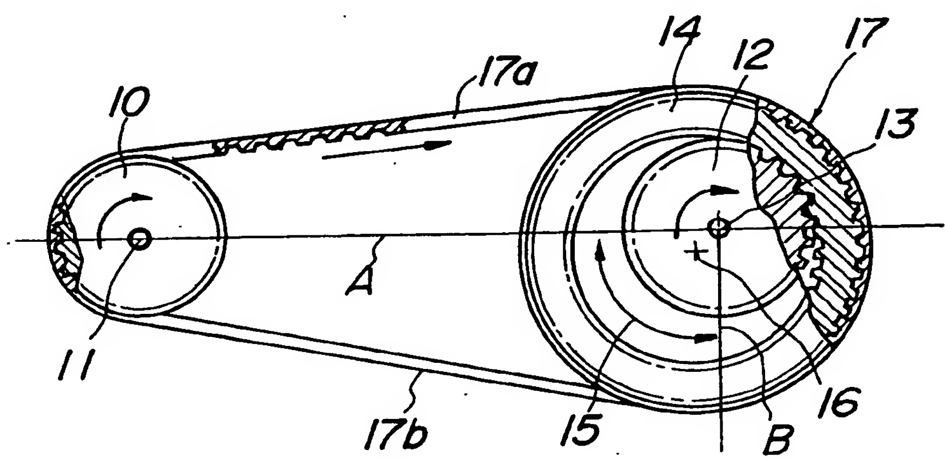

FIG. 3

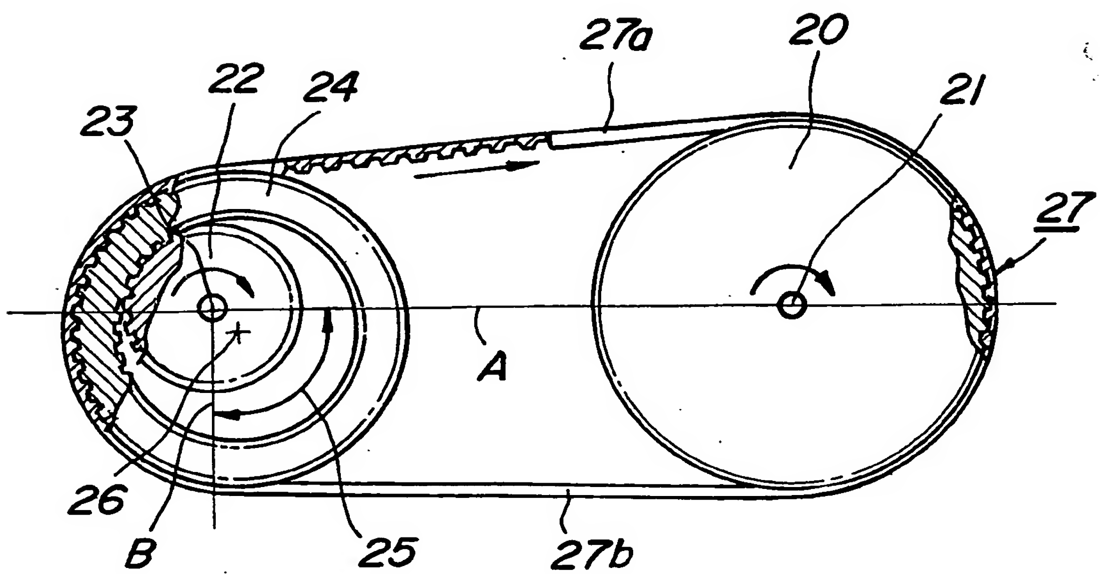

FIG. 4

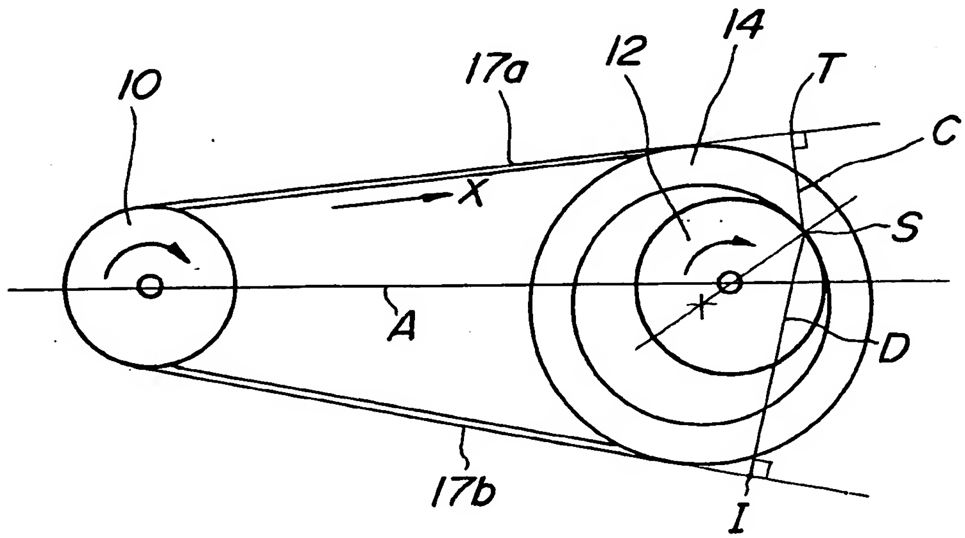

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FIG.5

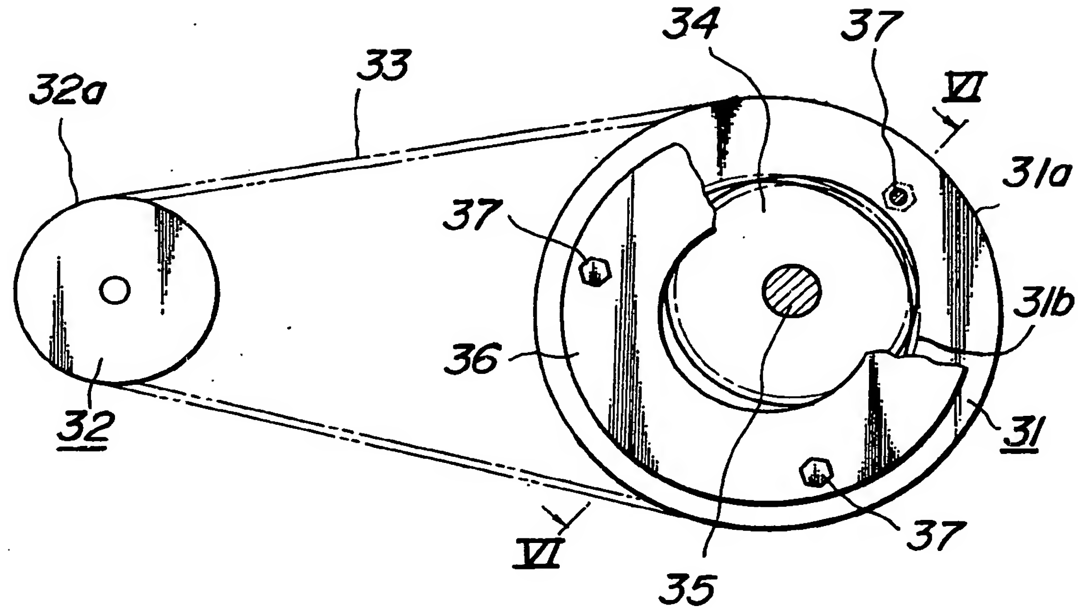

FIG.6

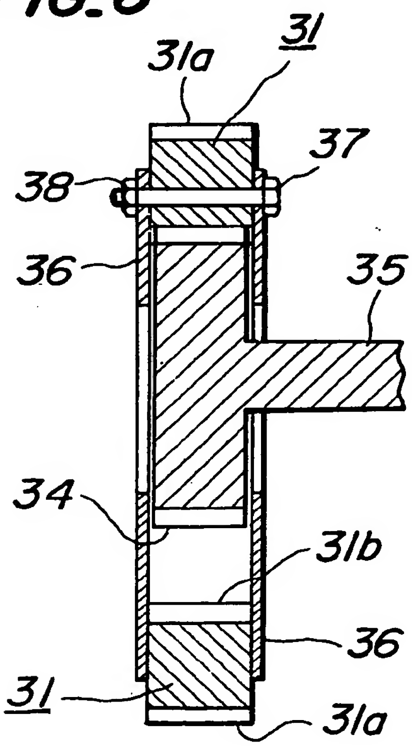

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FIG_7

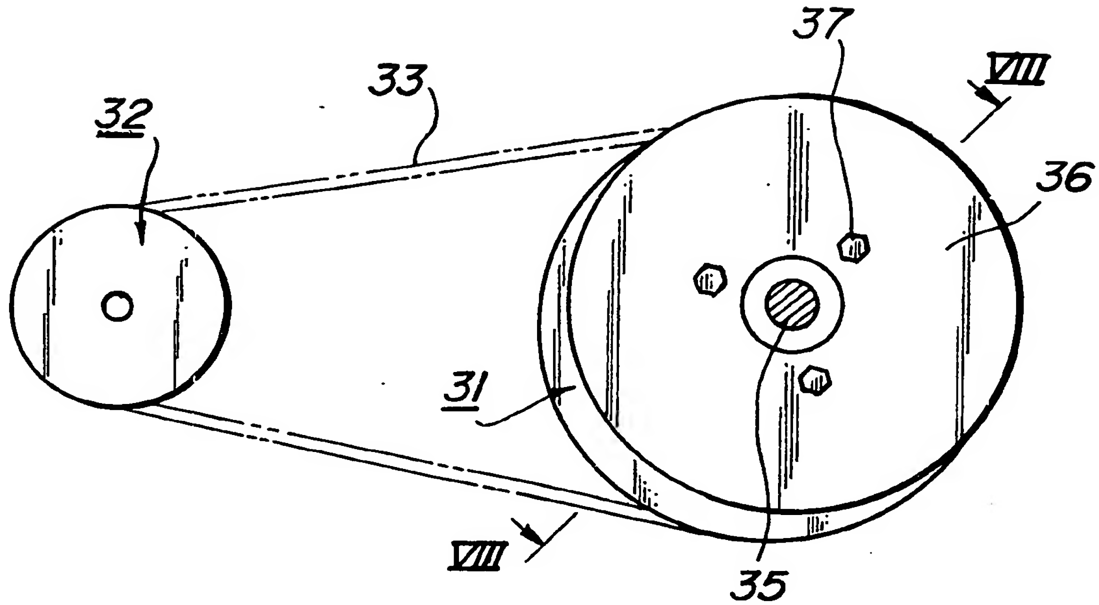

FIG_8